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Fission Product Washoff from Structural Alloys: Preliminary Tests

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FISSION PRODUCT WASHOFF FROM STRUCTURAL ALLOYS: PRELIMINARY TESTS*

E. C. Beahm and W. E. Shockley

1. INTRODUCTION

In a combined water ingress and depressurization accident, fission products deposited on alloy surfaces may be washed off by liquid water. When the fission products were deposited, the alloy surfaces may have been metallic, oxidic, or even reduced to a carbide. The extent and chemical forms of the fission product deposition may depend on the type of surface that is presented to the flowing gas in the primary system. These factors, in turn, may result in variations in the fraction of fission products which are washed off in a water ingress accident. The variables which may influence the washoff include: (1) water temperature, (2) water pH, (3) contact time, and (4) surface oxidation state before and during washoff. Even if the chemical forms of deposited fission products were known precisely, and they are not, it would be difficult to predict the extent of washoff. At the temperature range of interest, between 250 and 300°C, the dielectric constant of water is much lower than at room temperature, and its properties as a solvent are changed from what may commonly be expected from beaker-on-benchtop experiments.

2. DESCRIPTION OF EXPERIMENTS

The experimental system used to study fission product washoff consists of a stainless steel autoclave, which is heated electrically, and a high-pressure water pump. A schematic of the system is shown in Fig. 1. A specimen holder, as shown in the expanded flow path in Fig. 1, allows water to flow up a 1-in. tubular section of alloy and out over the side. The water then falls to the bottom of the autoclave where it may be sampled. The conditions where the autoclave system may be operated are given in Table 1.

The high-pressure pump enables water to be pumped into the autoclave, and over the test specimen, at the test pressure and temperature conditions. The pump flow rate can be varied between 0.1 and 10.0 cm^3/min.

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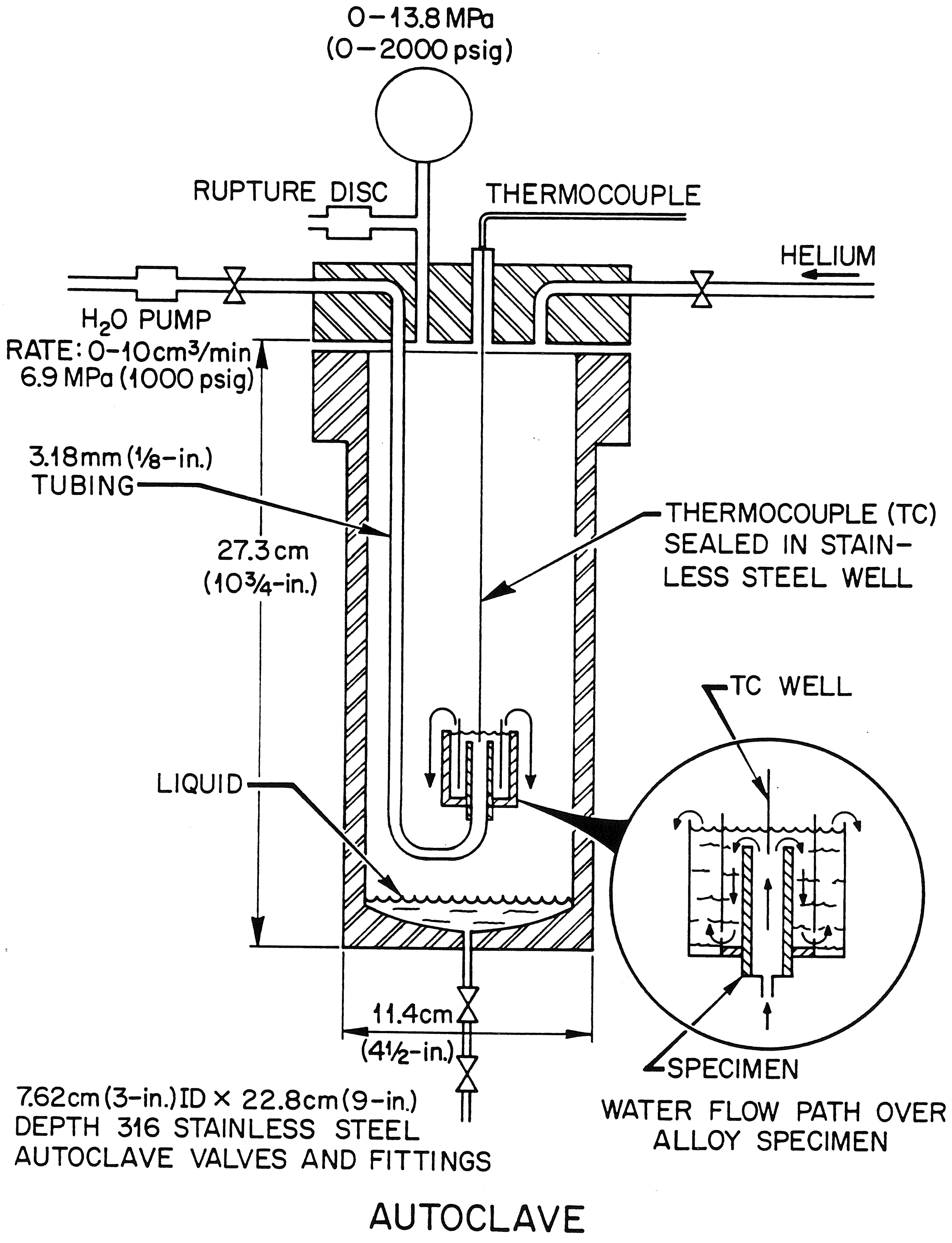

FIGURE 1

Table 1. Conditions in autoclave system

Environment	He/H_2O
Temperature	Room temperature to 300°C
Pressure	Consistent with retaining condensate at temperature, rupture disc would relieve pressure at 2075 psig at 343°C
Contact time	0.1–10 h

During a test, aqueous samples are periodically withdrawn while the system is at operating temperature and pressure. The aqueous samples are gamma counted to determine the amount of fission product radionuclide. In addition, aqueous samples are extracted to determine the fractions of iodine in the form of I^- (iodide ion), I_2 (elemental iodine), and organic iodine. In this procedure, the aqueous sample is extracted with isooctane which removes iodine in the form of I_2 and organic iodide. The isooctane is then back extracted with a 0.1 *M* NaOH solution to remove I_2. The aqueous sample, after extraction, is counted to obtain the fraction as I^-, the isooctane is counted to obtain the fraction as organic iodide, and the 0.1 *M* NaOH solution is counted to obtain the fraction as I_2.

The alloy test specimens are prepared by a cleaning procedure consisting of washing in KNOX laboratory cleaner, rinsing with distilled water, soaking and washing in acetone, drying, soaking and washing in ethyl alcohol, and a final drying. Fission products are deposited on the test specimens in an apparatus described in ref. 1. The specimens are gamma counted before and after a test to determine the washoff fraction.

3. EXPERIMENTAL RESULTS

Two iodine washoff tests have been run with 2 1/4 Cr–1 Mo alloy. Pure water was sparged with argon before the tests to deaerate the washoff water. The 2 1/4 Cr–1 Mo specimens were tubular sections 1 in. in length by 3/8 in. OD. The water flow rate over these specimens was 1 cm^3/min. Table 2 gives the data for these tests. The extraction of aqueous samples from both tests showed that the iodine was present only as iodide ion (I^-). These extractions were begun <1 min after the samples were drawn.

Table 2. Iodine washoff test data, 2 1/4 Cr–1 Mo alloy

Alloy surface	Temperature of iodine deposition (°C)	Temperature of washoff water (°C)	Percentage of iodine washed off	Total volume of washoff water (cm^3)
Reduced to metal with H_2	300	275–278	76.5	48
Oxidized by CO/CO_2 gas	500	245–253	56.0	66

In both tests more than half of the deposited iodine washed off the specimen. The portion of the iodine that washed off during the tests did so very readily; i.e., the washoff fraction was already present at the time of the first sample, and subsequent water flow merely diluted the iodine already washed off. However, the iodine that remained on the specimens was very difficult to remove even with decontamination methods such as heating in citric acid and hydrogen peroxide baths.

The results of these two initial tests indicate that iodine was present on the alloy in two different forms, one which dissolved very quickly and one which did not dissolve at all. Subsequent tests will be necessary to determine what factors influence the extent of these two fractions.

4. REFERENCES

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