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TITLE

DEVELOPMENT TEST IP-646-D, IRRADIATION SERVICE
REQUEST HAPO 278, OUTGASSING RATE OF TRITIUM
AT HIGH TEMPERATURES AND HYDRIDING CORROSION
OF ZIRCALOY-2

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DEVELOPMENT TEST IP-646-D
IRRADIATION SERVICE REQUEST HAPO 278
OUTGASSING RATE OF TRITIUM AT HIGH TEMPERATURES
AND HYDRIDING CORROSION OF ZIRCALOY-2

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A. E. DeMers

December 30, 1963

By Authority of *RM-10en*
4-5-94, #CGPR-2

By *J.E. Savely 4-17-94* HANFORD ATOMIC PRODUCTS OPERATION
Verified By *Jerri Maley, 4-18-94* RICHLAND, WASHINGTON

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DEVELOPMENT TEST IP-646-D
IRRADIATION SERVICE REQUEST HAP0 278
OUTGASSING RATE OF TRITIUM AT HIGH TEMPERATURES
AND HYDRIDING CORROSION OF ZIRCALOY-2

OBJECTIVE

The objective of this test is to determine the hydriding corrosion rate of Zircaloy-2 at high temperature in a damp helium atmosphere and to determine the outgassing rate of tritium generated in a lithium-aluminum alloy.

BASIS AND JUSTIFICATION

A study has been initiated to evaluate the feasibility of tritium production in N Reactor using lithium-aluminum alloy target material. The projected operating temperature of N Reactor (280 C) imposes possible problems of swelling and tritium escape not encountered in previous experience with tritium production in older reactors.

In the same irradiation capsule, samples of Zircaloy-2 will be exposed to a damp helium atmosphere to obtain additional knowledge concerning hydrogen absorption and corrosion rates. The data obtained from this test will justify proposed limits on prescribed atmosphere conditions which are compatible for both graphite stack and Zircaloy process tubes.

CAPSULE DESIGN

The capsule consists of a 2-1/2 inch OD by 22-inch long aluminum can sealed at both ends and divided into two sections. The first section is a 1-1/2 inch OD aluminum tube, 8 inches long and containing 24 samples of Zircaloy-2. The samples are discs 1 inch OD by 1/4 inch ID by 1/32 inch thick. They are interspaced with aluminum discs for heat transfer purposes. Three thermocouples and a gas inlet tube are brought in through the stainless steel end caps.

The second section consists of a 1-1/2 inch OD by 8-inch long aluminum tube containing a lithium-aluminum cylindrical target element 1/8 inch thick. Two thermocouples and a 1/2 inch aluminum vacuum tube will lead into this section. Both sections will be wrapped with insulated nichrome V heater wire. (See Figure I).

OPERATING CONDITIONS

The capsule temperature will be controlled at 400 C in the first section (Zircaloy-2 specimen) and 300 C for the second section, but will be outgassed at 450 C for short periods (ten minutes to one hour).

The hydriding section will have helium gas flowing through it at 100 ml/min at atmospheric pressure. The helium gas will contain small amounts of water vapor, 1% hydrogen and 0.5% carbon monoxide. Gas composition will be prepared as used by passing the helium gas through potassium acetate solution and over 900 C graphite chips. The flow rate will be controlled by flow meters and diaphragm valves. The exhaust gases will be vented to the building exhaust system. Temperatures for both sections will be controlled by current adjusting magnetic amplifiers and saturable reactors. Power supplied to the heaters may vary between 0-1500 watts, but are

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OSION AND LITHIUM-ALUMINUM CAPSULE (NO SCALE)

B-B (FULL SCALE)

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HYDRIDING CORROSION AND LITHIUM-ALUMINUM CAPSULE (NO SCALE)

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OPERATING CONDITIONS (continued)

expected to operate at 500 watts. Over temperature control is provided by Minneapolis-Honeywell Protect-O-Vane units set 20 C above the operating conditions. The capsule heaters will be shut off during reactor outages by a relay which will be tripped by the X-level water supply pressure.

An out-of-reactor hydriding capsule identical to the in-reactor capsule will be operated at the same temperature and gas atmosphere conditions as the in-reactor capsule.

OUTGASSING PROCEDURE

The inner capsule will be evacuated at the beginning of the irradiation. During the low temperature irradiation, when the generated tritium level and rate of evolution are low, the capsule pressure will be monitored weekly. When the temperature is intentionally raised, the pressure will be monitored daily. The projected total exposure is one month. This will produce a tritium level in the aluminum lattice of approximately 10 cc (STP) per cc of aluminum. It is expected that the accumulation of tritium in the vacuum system will be less than one cc (STP) during a single daily run. After each run, the accumulated tritium will be vented to the stack through the forepump. The accumulated tritium released to the stack each day will be a maximum of one cc, and will be bled off to the stack over a two-hour period. The calculated curie value of one cc of tritium is 2.6 curies. The maximum permissible inhalation concentration of tritium for continuous working conditions is 5×10^{-6} microcuries/cc. KE Reactor stack exhaust flow is 2.2×10^{11} cc/hr. This will give an H³ concentration at the top of the stack of 5.9×10^{-6} microcuries/cc which is slightly above the MPC, but still an insignificant concentration of tritium.

To measure the outgassing rate, the measuring system is first evacuated to the aluminum valve (normally closed) with the second diffusion pump and forepump. With the mercury cut-off valve closed, the aluminum valve is opened to bleed the accumulated gas into the measuring system. A manometer is included in the system to measure possible gas accumulation beyond the range of the McLeod gauge. Next, the first diffusion pump is started to concentrate the gas into the McLeod gauge section. The outgassing rate will be measured by observing the change in pressure with time. Gas will be removed from the McLeod gauge as required by opening the mercury cut-off valve and pumping the gas with the second diffusion pump. The gas will be pumped either to the stack through the forepump or into a gas container for mass spectrometer analysis.

The outgassing system will be enclosed in an aluminum and plastic box. The top of the box will be connected to the building vacuum system to prevent the escape of any tritium gas onto the X-levels.

REACTOR AND FACILITY

The capsule will be charged into the flat flux region of the 2A General Purpose Facility at KE Reactor.

The facility will be operated in accordance with KE Processing DOP 3.3.5, which provides for an immediate reactor shutdown upon receipt of temperature and pressure alarms from the facility. The facility will not be in the reactor safety circuit.

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HEAT GENERATION

The heat generation of the capsule will be 2800 watts with an additional 3000 watts of electrical heat available.

CMK ABSORBED

Ten nominal.

OUTAGE TIME REQUIRED

None

DISCHARGE PROCEDURE

The capsule will be removed by employing the snout facility cask train and procedure. This is accomplished by pulling the capsule and capsule leads into the cask train and severing the capsule leads from the capsule with the guillotine. The capsule leads will be disposed of by the long rope method and buried. Both of the above procedures have been demonstrated many times in the past removing snout assemblies and various test capsules.

HAZARDS

The reactor hazards will not be increased significantly due to the presence of the capsule in the facility. There is an H³ inhalation hazard associated with this test when sampling and exhausting the accumulated tritium prior to sampling. The entire gas sampling and exhaust system will be static helium-leak tested before and after charging the capsule. The gas sampling system will be enclosed and be under a vacuum at all times to prevent escape of tritium gas to working areas. The exhausting of accumulated gases to the stack will be done over a two-hour period to dilute the tritium below the maximum permissible limit prior to exhausting to the atmosphere.

RESPONSIBILITYIrradiation Processing Department

Irradiation Testing will be responsible for charge-discharge of the capsule, operation of the facility, gas sampling, and routine data collection.

KE Processing will be responsible for compliance with DOP 3.3.5.

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Engineer
Irradiation Testing

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