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DEVELOPMENT TEST IP-556-D, IRRADIATION SERVICE
REQUEST HAP0-278, OUTGASSING RATE OF TRITIUM
AT HIGH TEMPERATURES

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DEVELOPMENT TEST IP-556-D
IRRADIATION SERVICE REQUEST HAP0-278
OUTGASSING RATE OF TRITIUM AT HIGH TEMPERATURES

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RICHLAND, WASHINGTON

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DEVELOPMENT TEST IP-556-D
IRRADIATION SERVICE REQUEST HAP0-278
OUTGASSING RATE OF TRITIUM AT HIGH TEMPERATURES

Objective

The test objective is to determine the effect of radiation and temperature on the outgassing rate of tritium generated in a lithium-aluminum alloy by neutron irradiation.

Basis and Justification

A study has been initiated to evaluate the feasibility of tritium production in N Reactor by the reaction:

using lithium-aluminum alloy target materials. 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 the older reactors at lower temperatures. To determine the combined effects of temperature and radiation on tritium escape, an in-reactor capsule experiment will be run in which the outgassing rate from an irradiated lithium-aluminum alloy is measured at controlled temperatures in an in-reactor test facility. The terminal in-reactor outgassing rate will be compared to the outgassing rate from a similar sample in a laboratory apparatus to evaluate possible effects of radiation.

Capsule Description

The capsule will consist of two concentric aluminum tubes. (See Figure 1). The outer tube will function to isolate the heater windings and inner capsule from the outer atmosphere. Dimensions of the outer tube are 2.90 inches OD, 0.06 inch wall, 11 inches long. The inner tube functions as a container for the lithium-aluminum alloy targets. The inner tube dimensions are 1.4 inches ID, 0.050 inch wall, 8.12 inches long. An aluminum alloy containing enriched lithium (40% Li^6) will be used as the target material. The target will consist of 16 Li-Al alloy discs, 1.39 inches in diameter by 1/4 inch thick, with a 3/16 inch diameter hole in the center. A 3/16 inch diameter aluminum rod mounted at the center of the inner tube will serve as a suspension for the discs and also as a thermocouple well (1/16 inch bore). The discs will be spaced 1/4 inch apart with aluminum spacers.

The inner tube will be heated with Nichrome-V windings. Two thermocouples will be placed in the inner capsule, one at the center of the tube and one near the outer edge.

The capsule is designed to operate at approximately 150 C, unheated. The estimated total nuclear heat generation in the capsule is 820 watts, assuming 1 watt/gm for aluminum. It will be operated at this temperature until the desired tritium

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concentration has been generated in the lithium-aluminum alloy discs, approximately one month. The temperature will then be raised and the gas evolution rate will be measured with a vacuum system located on the X-1 level. The temperature will be raised by: a) addition of nitrogen to the dry bore of the test facility to change the thermal conductivity; b) and by supplying 0-300 watts to the heater winding as required. The dry bore of the test facility will normally operate with helium gas around the capsule. When nitrogen is added to the facility, the helium gas in the facility will be bled off to the reactor stack. This will be accomplished by running a tubing line from the facility outlet nozzle to the old beta sample room, through a valve, and then to a stack exhaust duct. The vacuum system will be connected to the inner capsule through a 1/4 inch aluminum tube welded to the inner aluminum tube. The upper capsule temperature will be 400 C or below and will be adjusted depending on the observed outgassing rate as the temperature is raised. The thermocouple leads, heater leads, and vacuum system lead will all be contained in a 1/2 inch diameter aluminum tube welded to the outer capsule and brought out of the reactor through spiral grooved shielding pieces. The 1/2 inch tube will be sealed to the nozzle cap to prevent the temperature control gas from escaping onto the X-level.

Capsule temperatures will be controlled with a current adjusting type Minneapolis-Honeywell magnetic amplifier. Power supplied to the heater will be 0-300 watts at 110 volts AC. Over-temperature protection is provided by a Minneapolis-Honeywell Protect-O-Vane and a fused Variac at the power output.

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 1 cc, and will be bled off to the stack over a two-hour period. The calculated curie value of 1 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 H^3 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. (See Figure 2.) 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

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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 tube-in-tube General Purpose Facility at KE Reactor. The annulus between the tubes will have continuous cooling water flow.

Development Test IP-469-D, Supplement A, authorizes the irradiation of a Zircaloy-2 resistivity capsule in the 2A test facility. Since both capsules cannot be charged into the 2A test facility, this Development Test authorizes the irradiation of IP-469-D in either the 2A or 3C test facility at KE Reactor.

The 2A test facility will be operated in accordance with KE Processing D.O.P. No. 3.3.5, which provides for a reactor shutdown upon receipt of temperature and pressure alarms from the facility. An analysis* of the capsule and facility indicates that a complete loss of water to the facility would result in melting of the capsule and facility in approximately five minutes. This is sufficient time to investigate a Panellit alarm prior to shutting down the reactor.

Heat Generation - 820 watts.

CMK Absorbed - Seven nominal

Shutdown Time Required - None

Discharge Procedure

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

Hazards

There are no reactor hazards associated with this test.

*HW-70129, Loss of Water to KE or KW Side Test Facilities

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There is an E^3 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 glass sampling system will be enclosed and will 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.

Responsibility

Irradiation Processing Department

Irradiation Testing

1. Charge-discharge of capsule and operation of facility.
2. Gas sampling and sample exhausting.
3. Routine data collection.

A.E. DeMers/Pr
Irradiation Testing

AE DeMers:bmr

- ① $AlLi^6$
- ② ALUMINUM SPACERS
- ③ HEATER WINDINGS
- ④ INNER CYLINDER
- ⑤ OUTER CYLINDER
- ⑥ GAS SAMPLING TUBE
- ⑦ HEATER LEADS
- ⑧ THERMOCOUPLES

TRITIUM OUT-GASSING CAPSULE

FIGURE I

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GAS SAMPLING MANIFOLD

FIGURE 2

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APPROVALS

an C. G. Lewis

CG Lewis, Manager
Testing

R. W. Reid

RW Reid, Manager
Process Technology

R. Nilson

R. Nilson, Acting Manager
Process and Reactor Development

RG Clough, Jr.

RG Clough, Jr., Manager
KE Processing

ER Astley

ER Astley, Manager
Applied Reactor Engineering

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